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5      **Method for Manufacturing An Organic Electroluminescent Display**

**Background of the Invention**

1. Field of the Invention

10      The present invention relates generally to a method for making organic electroluminescent displays, and more particularly to a method for making cathode ramparts and insulating layer of an organic electroluminescent display through only one photo mask.

2. Description of the Related Art

15      With the advent of the information technology age, there is an increasing demand for high-quality electro-optical displays, in which liquid crystal displays (LCD) are the most popular. A LCD backlight module comprising a light guide and a reflective plate is utilized for introducing the light beams, emitted from the cold cathode fluorescent lamp, vertically to the liquid crystal display panel, in which  
20      liquid crystal contained therein controls the illuminance of the LCD. Conventional LCDs have a limited view angle and require very complicated manufacturing processes, which result in high manufacturing costs and relatively low yields. However, organic electroluminescent displays (OLED) have larger view angles and can be produced through less complex manufacturing process. These advantages  
25      based on the self-luminance of the organic elements in the organic electroluminescent displays, which results in the unrestricted view visual, more

natural colors displayed, increased operational temperature range and shorter response time.

With reference to Fig. 1, the structure of a conventional organic electroluminescent display 1 is shown. A glass substrate 2 carries a plurality of first display electrodes 3 arranged in parallel and a plurality of cathode ramparts 4 made of an electrical insulation material are formed on the substrate 2. The cathode ramparts 4 are arranged perpendicular to the first display electrodes 3 and apart from each other, and are protruded from the substrate and exposes at least portions of the first display electrodes 3. Each cathode rampart 4 at the upper part thereof has an overhang portion 7 protruded in a direction parallel to the substrate 2. Between the cathode ramparts 4, organic electroluminescent layers 5 are formed on the exposed first display electrodes 3, and a plurality of second display electrodes 6 are formed on the organic electroluminescent layers 5.

With reference to Fig. 2A-2G, conventional manufacturing processes of an organic electroluminescent display are shown. A plurality of first display electrodes 210 of stripe shapes arranged in parallel are formed on a glass substrate 200 by a sputtering process, as shown in Fig. 2A. A layer of insulating materials 220 are spin-coated on the substrate 200 with the first display electrodes 210 disposed thereon. Then, shadow masks are disposed on the insulating materials 220, and after a photolithography process, openings 225 having a direction perpendicular to that of the first display electrodes 210 are formed, and thereby exposing the first display electrodes 210 partially, as shown in the top view of Fig. 2B and the sectional view of Fig. 2C. Next, as shown in Fig. 2D, a layer of photoresistant materials 230 are formed on the insulating materials 200 having openings 225. With reference to Fig. 2E, photo masks 235 are formed on the photoresistant materials 230 and are illuminated by parallel light beams I. Due to the mask effect of the photo masks 235, only the portions of the photoresistant materials 230, i.e. the mesh areas, are illuminated by the light beams I. Subsequently, a developing process is conducted to

the photoresistant materials 230 so as to form a shape of cathode ramparts shown in Fig. 2F. Finally, organic electroluminescent material is formed on the exposed first display electrodes and then a plurality of second display electrodes are formed on the organic electroluminescent materials such that an organic electroluminescent display is completed.

In the prior manufacturing processes of an organic electroluminescent display, two photo masks are required for the formation of the cathode ramparts; the first photo mask is utilized for forming openings in the insulating materials, and the second photo mask is utilized for forming cathode ramparts.

### Summary of the Invention

The principal object of the present invention is to provide a method for manufacturing an organic electroluminescent display, which simplifies the manufacturing procedure, reduces the time and the cost required for manufacture and reduces the inaccuracy of alignment.

To achieve this object, the present invention provides a method for manufacturing an organic electroluminescent display, comprising the steps of:

forming a substantially transparent substrate; forming a plurality of first display electrodes arranged in parallel on said substrate; forming a non-photosensitive insulating layer on said substrate with first display electrodes disposed thereon; forming a photosensitive insulating layer on said non-photosensitive insulating layer; performing a photolithography process on said photosensitive insulating layer; developing said photosensitive insulating layer and etching said non-photosensitive insulating layer so as to form a plurality of photosensitive insulating layer and the non-photosensitive insulating layer having a shape with its longitudinal axis substantially perpendicular to the that of the first display electrodes, and the first display electrodes being exposed partly; forming an organic electroluminescent material on the exposed first display electrodes; and forming a plurality of second display electrodes on the organic electroluminescent material.

An alternative method for manufacturing an organic electroluminescent display according to the present invention comprises the steps of providing a substantially transparent substrate; forming a plurality of first display electrodes arranged in parallel on said substrate; forming a non-photosensitive insulating layer on said substrate with first display electrodes disposed thereon; pre-baking and -baking said non-photosensitive insulating layer; forming a photosensitive insulating layer on said non-photosensitive insulating layer, and pre-baking thereto; proceeding a photolithography process to said photosensitive insulating layer so as to define a

shape perpendicular to that of the first display electrodes, and proceeding a post-exposure baking thereto; disposing an aggregate composed of said substrate with said first display electrodes, said non-photosensitive insulating layer and said photosensitive insulating layer disposed thereon into developers, whereby said photosensitive insulating layer is partially removed through development and said non-photosensitive insulating layer is partially removed by etching, and thereby said first display electrodes are exposed partially; proceeding a final cure process to said aggregate; forming an organic electroluminescent material on the exposed first display electrodes; and forming a plurality of second display electrodes on the organic electroluminescent material.

The present invention further provides a method for manufacturing an organic electroluminescent display, comprising the steps of: forming a substantially transparent substrate; forming a plurality of first display electrodes arranged in parallel on said substrate; forming a first photosensitive insulating layer on said substrate with first display electrodes disposed thereon; forming a second photosensitive insulating layer on said first photosensitive insulating layer; performing a photolithography process on said first and second photosensitive insulating layers; developing said first and second photosensitive insulating layers simultaneously so as to form a plurality of first and second photosensitive insulating layers having a shape with its longitudinal axis substantially perpendicular to the that of the first display electrodes, and the first display electrodes being exposed partly; forming an organic electroluminescent material on the exposed first display electrodes; and forming a plurality of second display electrodes on the organic electroluminescent material,

wherein the photosensitivity of the first photosensitive insulating layer is different from that of the second photosensitive insulating layer.

Still another method for manufacturing an organic electroluminescent display according to the present invention comprises the steps of providing a substantially

transparent substrate; forming a plurality of first display electrodes arranged in parallel on said substrate; forming a first photosensitive insulating layer on said substrate with first display electrodes disposed thereon; forming a second photosensitive insulating layer on said first photosensitive insulating layer;

- 5 proceeding a photolithography process to said first and second photosensitive insulating layers so as to define a shape perpendicular to that of the first display electrodes; disposing an aggregate composed of said substrate with said first display electrodes, said first photosensitive insulating layer and said second photosensitive insulating layer disposed thereon into developers, whereby said first and second
- 10 photosensitive insulating layers are partially removed through development, and thereby said first display electrodes are exposed partially; forming an organic electroluminescent material on the exposed first display electrodes; and forming a plurality of second display electrodes on the organic electroluminescent material.

- 15 Additional advantages, objects and features of the present invention will become more apparent from the drawings and description which follows.

### **Brief Description of the Drawings**

The present invention will become more apparent from the detailed description given hereinbelow when read in conjunction with the accompanying drawings, which are given by means of illustration only and thus are not limitative of the present invention, in which:

Figs. 1 is a perspective view illustrating a structure of a conventional organic electroluminescent display;

Figs. 2A-2F are schematic views illustrating the conventional manufacturing processes of an organic electroluminescent display utilizing two shadow masks for forming cathode ramparts;

Figs. 3A-3E are schematic views illustrating the manufacturing processes of an organic electroluminescent display according to one embodiment of the present invention; and

Figs. 4A-4D are schematic views illustrating the manufacturing processes of an organic electroluminescent display according to another embodiment of the present invention.

### **Brief Description of the Reference Numerals**

1	organic electroluminescent display
2	glass substrate
3	first display electrode
4	cathode rampart
5	organic electroluminescent layer
6	second display electrode
7	overhang portion
200	substrate
210	first display electrode
220	insulating materials
225	opening

	230	photoresistant materials
	235	photo mask
	300	substrate
	310	first display electrode
5	320	non-photosensitive insulating materials
	330	photosensitive insulating materials
	335	photo mask
	340	organic electroluminescent materials
	350	metal conductive materials
10	400	substrate
	410	first display electrode
	420	first photosensitive materials
	430	second photosensitive materials
	435	shadow mask
15	440	organic electroluminescent materials
	450	metal conductive materials



### **Detailed Description of the Preferred Embodiment**

With reference to Figs. 3A-3E, the method for manufacturing an organic electroluminescent display according to one embodiment of the present invention is shown. First with reference to Fig. 3A, a layer of substantially transparent conductive materials, such as indium tin oxide (ITO) or  $\text{In}_2\text{O}_3\text{-ZnO}$ , is formed on a substrate 300, such as a transparent glass substrate or a flexible, light-transmitting plastic substrate, by a sputtering process. Next, photoresists are provided on the conductive material as shadow masks such that a plurality of first display electrodes 310 of stripe shapes arranged in parallel are formed from the conductive materials as anode electrodes of the organic electroluminescent displays after a photolithography process for removing the portions of the conductive materials unmasked by the photoresists.

With reference to Fig. 3B, a blanket of non-photosensitive insulating materials 320, preferably made of thermal type polyimide, is spin-coated on the substrate 300 with the first display electrodes 310 disposed thereon about 0.5-2 $\mu\text{m}$  thickness for covering both the first display electrodes 310 and the substrate 300 exposed. Then, a pre-baking process is conducted to the non-photosensitive insulating materials 320 to remove the solvent existed therein, and a -baking process is subsequently conducted thereto at a temperature between 120-180 C for 20 minutes to 1 hour to imidize the non-photosensitive insulating materials 320, and thereby a partial cross-linking effect occurs thereto.

With reference to Fig. 3C, a blanket of photosensitive insulating materials 330 is spin-coated on the non-photosensitive insulating materials 320 about 3-5 $\mu\text{m}$  thickness as negative photoresists. Then, a pre-baking process is conducted to the photosensitive insulating materials 330 to remove the solvent existed therein. Subsequently, photo masks 335 are disposed on the photosensitive insulating materials 330, and after a photolithography process, a shape perpendicular to the

first display electrodes 310 are defined in the photosensitive insulating materials 330, wherein the exposure is proceeded at 30-80 mJ/cm<sup>2</sup>. As shown in Fig. 3C, the portions of the photosensitive insulating materials 330 illuminated during exposure process is represented as mesh areas. Then, a post-exposure baking process is conducted at a temperature between 90-150 C for 30-120 seconds to remove the solvent in the photosensitive insulating materials 330.

The whole aggregate is then disposed into or sprayed with developers, such as TMAH 2.38%, at room temperature for 50-100 seconds, such that the photosensitive insulating materials 330 is partially removed through developing effect. After that, the non-photosensitive insulating materials 320 are partially removed through wet-etching by the developers due to the partial cross-linking effect during -baking process. Since the adhesion between the non-photosensitive insulating materials 320 and the photosensitive insulating materials 330 is weaker, the photosensitive insulating materials 330 is developed to be of a reversed trapezoid shape and the non-photosensitive insulating materials 320 is etched to be of a trapezoid shape as shown in Fig. 3D. It should be noted that the long side of the reversed trapezoid shape of the photosensitive insulating materials 330 is not shorter than that of the trapezoid shape of the non-photosensitive insulating materials 320, such that short circuit between the second display electrodes, which will be formed in the subsequent process, and the first display electrodes is avoided. Then, a final curing process is conducted at a temperature between 200-350 C for 30 minutes to 2 hours, and thereby completing the formation of the cathode ramparts.

Next, organic electroluminescent materials 340 are formed on the exposed first display electrodes 310, as shown in Fig. 3E. While producing single-color organic electroluminescent displays, an organic electroluminescent layer is coated through evaporation on the exposed first display electrodes 310. While producing full-color organic electroluminescent displays, RGB organic electroluminescent layers are formed in turn on the exposed first display electrodes 310 by using shadow masks.

Subsequently, metal conductive materials 350, such as Al, Mg-Al alloy or other suitable metal materials, are formed on the organic electroluminescent materials 340 as cathode electrodes of the organic electroluminescent displays.

Fig. 4A-4D are the schematic drawings illustrating the manufacturing processes of an organic electroluminescent display according to another embodiment of the present invention. In this case, a plurality of first display electrodes 410 made of, for example, ITO or  $\text{In}_2\text{O}_3\text{-ZnO}$  as anode electrodes of the organic electroluminescent display of stripe shape arranged in parallel are formed on a substrate 400. Then, first photosensitive insulating materials 420 and second photosensitive insulating materials 430 are in turn formed on the substrate 400 with first display electrodes 410 disposed thereon as negative photoresists, for example, as shown in Fig. 4B. It should be noted that the photosensitivity of the first photosensitive insulating materials 420 is greater than that of the second photosensitive insulating materials 430.

Next, photo masks 435 are disposed on the second photosensitive insulating materials 430 and a photolithography process is conducted to the second photosensitive insulating materials 430 and thus to the first photosensitive insulating materials 420 such that a shape perpendicular to the first display electrodes is defined therein. With reference to Fig. 4C, parallel light beams I incident to the second photosensitive insulating materials 430 and thus to the first photosensitive insulating materials 420. Due to the masking effect of the photo masks 435, only the portions of the second photosensitive insulating materials 430 and of the first photosensitive insulating materials 420 marked by mesh areas are illuminated by the light beams I. Subsequently, a developing process is conducted to the second photosensitive insulating materials 430 and the first photosensitive insulating materials 420 and thereby forming cathode ramparts of shapes shown in Fig. 4D. Finally, organic electroluminescent materials 440 are formed on the exposed first display electrodes 410, and metal conductive materials 450 are formed on the

organic electroluminescent materials 440 as cathode electrodes of the organic electroluminescent displays.

- 5 Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the present invention as recited in the accompanying claims.